Bronchoscopy in Lung Cancer

Appraisal of Current Technology and for the Future

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Abstract: Bronchoscopy in the new millennium spells an exciting time for the pulmonologist, which likens to Alice peering through the looking glass into a wonderland of miniaturized probes, optics, and technology that are advancing at a maddening pace. Although scientists continue to push the envelope using nanotechnology that may facilitate further miniaturization of probes to allow imaging at the cellular or molecular level, it is opportune to evaluate the strengths and weaknesses of available technologies and bronchoscopic techniques for the diagnosis and staging of lung cancer, in its early detection and palliation. We appraise current technologies and what they hold for the future.

Key Words: Bronchoscopy, Diagnosis, Staging, Palliation, Lung cancer.

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Bronchoscopy dates back to the late 18th century where rigid illuminating tubes were used to examine the tracheobronchial tree.[1] Subsequently, with the introduction of the fiberoptic bronchoscope by Ikeda et al.,[2] bronchoscopy has revolutionized the practice of pulmonary medicine. In lung cancer, because of advances in real-time imaging and catheter-based techniques, bronchoscopy not only remains pivotal in diagnosis and staging but also allows therapeutic intervention for airway restoration in patients with central airway obstruction and treatment of early detected central airway cancers. For peripheral lung nodules that are beyond the visibility of the bronchoscope, computed tomography (CT) guided, navigational methods, and endobronchial ultrasonography (EBUS) facilitate accurate targeting. Because bronchoscopy allows access to the lung, it is also a tool that enables researchers to better understand lung carcinogenesis, discover biomarkers for early detection and prognostication, and assess tumor response to targeted therapy by in vivo microdynamic imaging.[3–5]

DIAGNOSIS

Conventional bronchial washing, brushing, and endobronchial and transbronchial biopsy have variable yields depending on tumor location and accessibility. For endobronchial tumor, forceps biopsy gives the highest yield (74%) compared with brushing (59%) and washing (48%). The yield is increased further to 88% when these modalities are combined. For peripheral lung lesions, transbronchial brush under fluoroscopy gives the highest yield (52%) followed by transbronchial biopsy (46%) and bronchial washing (43%). When bronchial washing, fluoroscopic-guided transbronchial biopsy, and brush are combined, they improve the yield to 69%.[6] Addition of needle aspiration for endobronchial, submucosal, peripheral pulmonary lesion, or peribronchial lymph node has been demonstrated to enhance diagnostic yield and is cost effective by obviating further need of invasive interventions and unnecessary open-close thoracotomies.[7,8]

Targeting a solitary pulmonary nodule (SPN) detected on CT scan presents a challenge because sensitivity of bronchoscopy for detecting malignancy in SPN is dependent on size of the nodule, its proximity to the bronchial tree, presence of CT bronchus sign (Figure 1), and prevalence of cancer in the population of interest.[9] For SPN measuring more than 2.5 cm, the yield from fluoroscopic-guided transbronchial biopsy is 62%, but when the SPN is less than 2.5 cm, the yield falls below 40%.[10] A major advance is the multidetector helical CT that allows data acquisition of the entire thorax during a single breath hold and reformatting of axial images into three-dimensional virtual bronchoscopy.[11] This has led to more precise targeting of peripheral pulmonary lesion for biopsy using either electromagnetic steering probe or ultrathin bronchoscope.[12–14]

Electromagnetic navigation bronchoscopy (ENB, SuperDimension; Plymouth, MN) requires uploading of patient's chest CT data and selection of reference anatomic landmarks with virtual bronchoscopy before the procedure. The patient is then placed on an electromagnetic board and a sensor probe within a guide sheath (GS) inserted through the working channel of bronchoscope is used to align preselected reference points with patient's own anatomic landmarks. The probe is steered toward the target, and tissue sampling is performed with forceps, needle, or curette guided by sheath after withdrawal of the sensor probe. ENB is not real time

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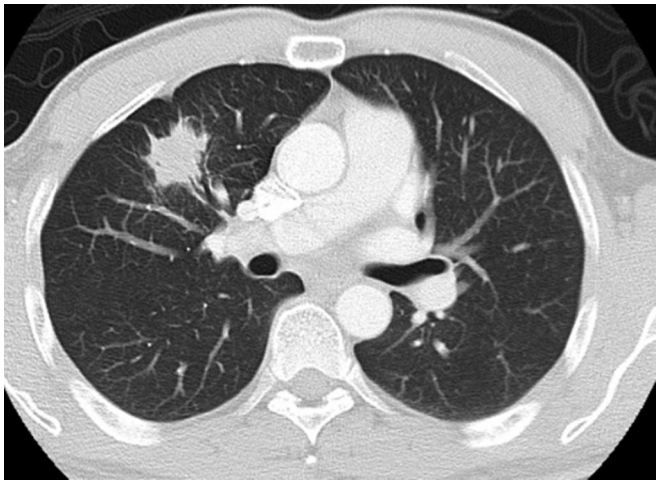


FIGURE 1. Computed tomography bronchus sign.

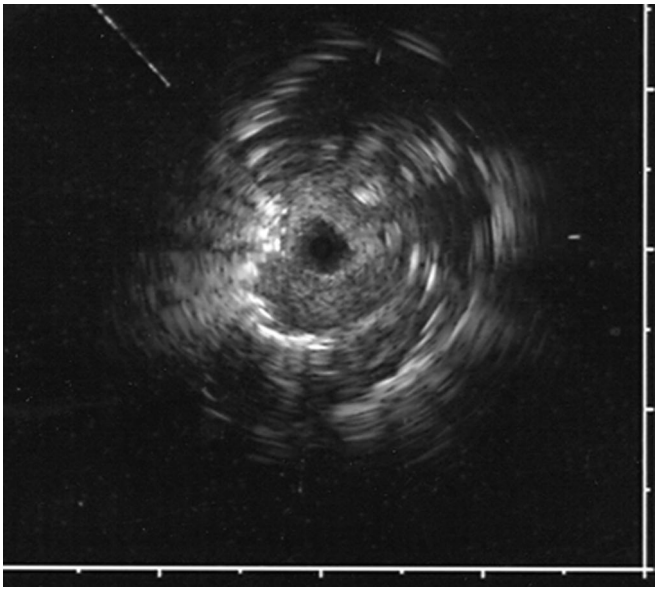


FIGURE 2. Endobronchial ultrasonography radial probe within pulmonary nodule.

because the uploaded CT data are acquired during patient's breath-hold, hence if confers a diagnostic accuracy of 69 to 74% and pneumothorax rate of 3%.[13,14] Although positive yields are not affected by location or size, median size of nodules biopsied was more than 2 cm. Thus patient's spontaneous respiration makes localization of small nodules less than 2 cm in the lower lobes and close to the pleura challenging.[14,15] The cost of ENB system is US $150,000 and another US $1000 for each disposable catheter. Because of the exorbitant cost of ENB, similar modification has been attempted using the ultrathin bronchoscope and with good results.[12]

EBUS with radial probe is useful for sampling peripheral lesions. A prospective randomized study demonstrates the superiority of EBUS-guided transbronchial biopsy (75%) over fluoroscopic-guided transbronchial biopsy (31%) for pulmonary nodules less than 3 cm. For pulmonary lesions more than 3 cm, no difference in diagnostic capability between the procedures is observed.[16] A technique that incorporates a GS through which the miniaturized EBUS radial probe (UM-S20–20R, Olympus) is inserted, the GS covered probe is introduced into the lesion through the working channel of bronchoscope, the radial probe is then withdrawn, and brush or biopsy forceps is guided by sheath to the lesion for biopsy. Kurimoto et al.[16] have reported that diagnostic yield is higher when the radial probe is located within the lesion (Figure 2) than when it is adjacent, efficacy of EBUS-GS method does not seem to be affected by tumor size and gives good yield even for lesions measuring 10 mm. Similarly, EBUS-GS is also demonstrated to be useful for fluoroscopically invisible SPN.[17] A difficulty encountered is in targeting small pulmonary lesions that are peripheral in location and close to the pleura, which has prompted the combined application of ENB and EBUS. In this prospective study, patients were randomized to undergo ENB alone, EBUS alone, or combined ENB-EBUS. In the combined modality group, patients underwent navigation bronchoscopy first with locatable sensor within catheter. When the target was close, the sensor was removed and the EBUS probe was inserted through the catheter. Forceps biopsies were performed after EBUS confirmation that the catheter was close to the target without fluoroscopy. Diagnostic yield from combined ENB-EBUS (88%) was significantly higher than ENB (59%) or EBUS (69%) alone, which was also observed according to lesion size, lobar distribution, and malignant pathology. The overall incidence of iatrogenic pneumothorax was 6%, which was not different in the three groups. Better yield achieved with combined modality was attributed to overcoming deficiencies of one technology with the strength of the other. ENB allows navigation of the EBUS probe to the lesion, and EBUS facilitates real-time visualization and confirmation of target.[18]

STAGING

Another indication for transbronchial needle aspiration (TBNA) is in the staging of lung cancer. Conventional TBNA performed without real-time imaging has a variable yield of 20 to 74%. The puncture site for enlarged lymph nodes is first determined by flipping over CT images for better correlation with the endoscopic view. However, fear of inadvertent puncture of neighboring vascular structures, damage to the bronchoscope, technical difficulties with needle, and inadequate specimen for diagnosis, TBNA is not routinely practiced.[19] Strategies have been proposed to improve the yield of conventional TBNA, which include minimum passes per lymph node station,[20] direct smear technique for specimen preparation,[21] rapid onsite evaluation by cytopathologist,[22] CT,[23] and radial probe EBUS guided.[24] With the advent of virtual positron emission tomography/CT bronchoscopy, it is possible that TBNA yield can be markedly increased by targeting PET positive lymph nodes using electromagnetic navigational technology[25] and puncture sites determined by the sensor probe.[13]

Notably, another major advance in mediastinal staging is the incorporation of curvilinear ultrasound to the tip of the bronchoscope that produces sectorial imaging of the lymph nodes. Coupled with color flow Doppler, EBUS allows safe real-time aspiration of mediastinal lymph nodes by avoiding surrounding vascular structures (Figure 3), and accuracy with this technique is reported between 89% and 97%.[26,27] In fact, EBUS coupled with endoscopic ultrasound transesophageal sampling of enlarged lymph nodes in the mediastinum achieve a diagnosis in 94%, a figure comparable with mediastinoscopy but performed in a noninvasive manner. Both techniques either singly or combined provide access to hilar, pulmonary ligament, para-esophageal, and adrenal lymph nodes that would otherwise be inaccessible with the mediastinoscope.[28]

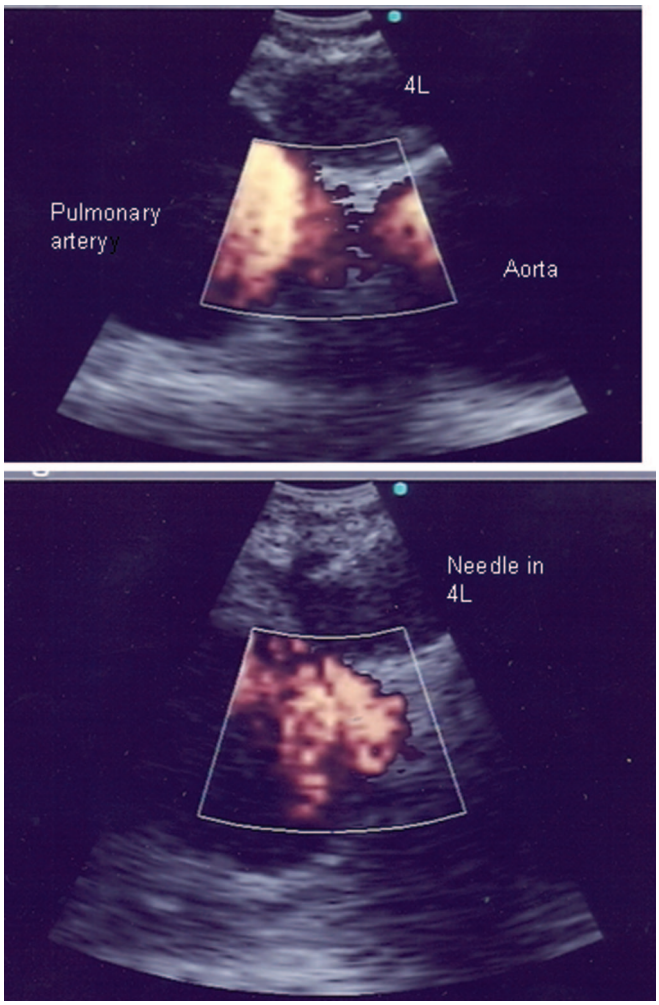


FIGURE 3. Real-time endobronchial ultrasonography transbronchial needle aspiration of left paratracheal lymph nodule.

PALLIATION OF CENTRAL AIRWAY OBSTRUCTION DUE TO LUNG CANCER

Malignant central airway obstruction is a significant cause of morbidity and mortality. Approximately 30% of patients with lung cancer will present with airway obstruction and 35% of this group will die of complications such as hemoptysis, postobstuctive pneumonia, and asphyxia. Although imminent asphyxiation could be temporarily relieved by endotracheal intubation and mechanical ventilation, airway recanalization by bronchoscopic methods and stent placement provide rapid relief of symptoms and allow time for the institution of chemoradiotherapy for sustained palliation, improved quality of life, and prolonged survival.[29] Selection of a therapeutic strategy depends on the type of lesion (Figure 4), acuity of presentation, the patient's general health status, and physician's expertise (Table 1).

Techniques for Immediate Airway Recannalization

Laser Therapy

The most widely used laser for the treatment of endobronchial tumors is the Neodymium-Yttrium-Aluminum-Garnet (Nd-YAG). Because the Nd-YAG laser wavelength is poorly absorbed by quartz material, it can be transmitted through a flexible fiber. The flexibility of the fiber enables distal airway lesions to be treated with either the rigid or flexible bronchoscope, and the versatility of the laser allows for tissue coagulation at low power and vaporization at high power.

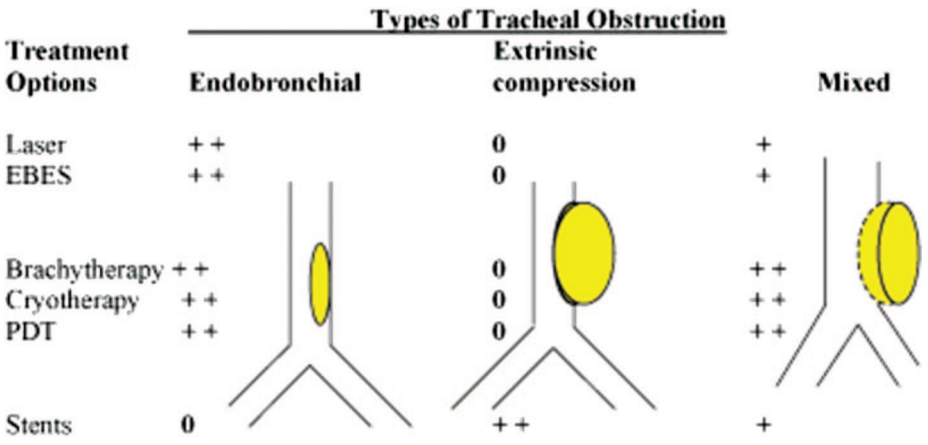
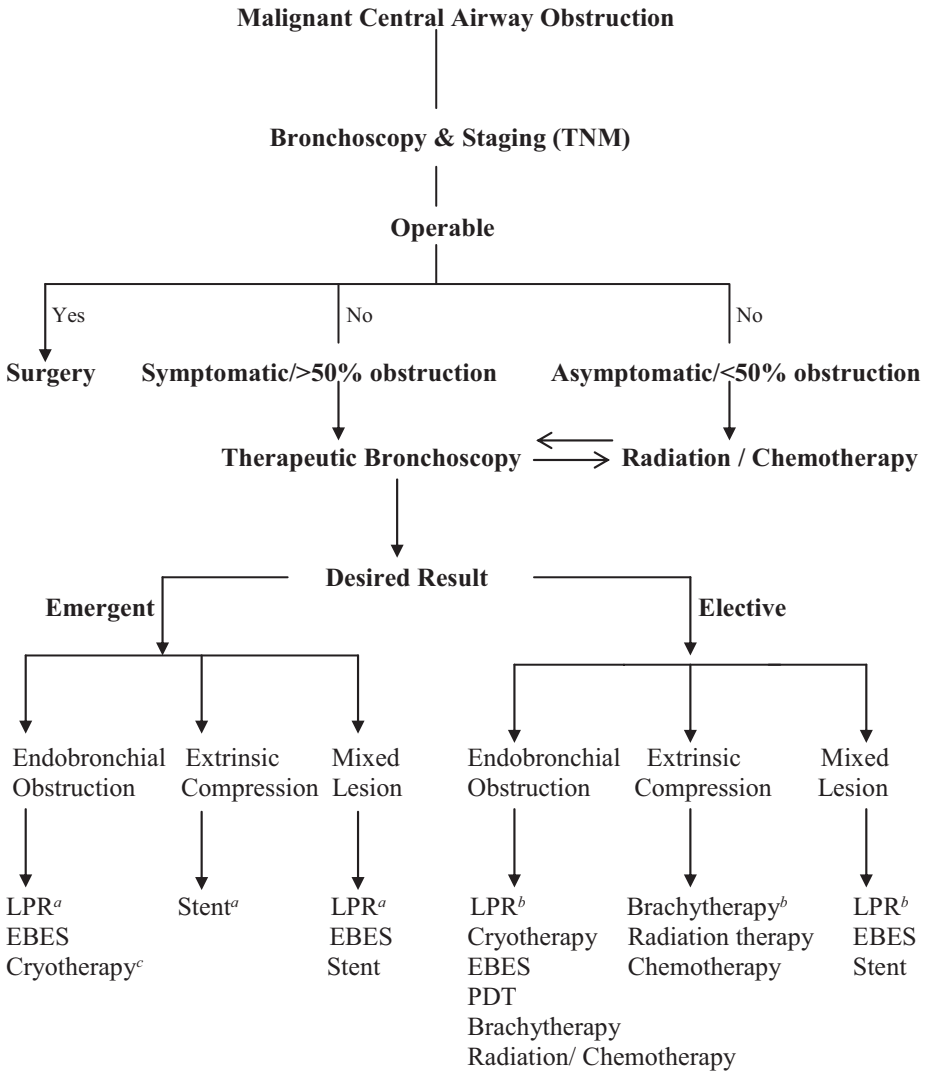


FIGURE 4. Three main types of tracheal obstruction and management.

TABLE 1. Algorithm for the Management of Malignant Airway Obstruction



[a] Followed by chemotherapy ± radiation therapy
[b] Can be used singly or in combination
[c] in selected cases using special cryoprobes

LPR, laser photoresection; EBES, endobronchial electrosurgery; PDT, photodynamic therapy.

Nd-YAG laser can be used to restore airway patency emergently or electively, and effectively debulk tumors by a combination of coring out techniques, deep tissue coagulation, and vaporization.[30] Laser photoresection of a large endobronchial tumor (Figure 5) is very effective not only for symptom palliation such as cough, dyspnea, and hemoptysis but also in achieving endoscopic, radiographic, spirometric, and quality-of-life improvements.[31,32] Timely recognition and prompt intervention avoid mechanical ventilation for patients in extremis and facilitate weaning and successful extubation in those who are mechanically ventilated.[33] Factors that influence the outcome of laser therapy are listed in Table 1.

Endobronchial Electrosurgery and Argon Plasma Coagulation

Endobronchial electrosurgery (EBES) is as effective as the laser for tumor ablation and control of hemoptysis, but EBES is cheaper and portable. Although the new diode lasers are designed to be portable, they are still located in major operating rooms and require special connection ports for

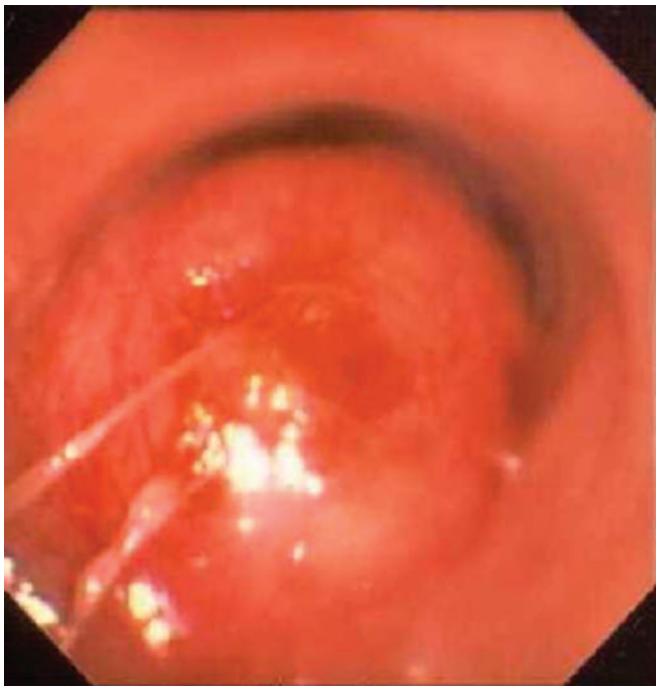


FIGURE 5. Favorable endobronchial tumor for laser.

application. EBES is considered an effective alternative to laser and can be performed through rigid or flexible bronchoscope with a grounded neutral plate attached to the patient. It is contraindicated for patients with cardiac pacemaker. EBES is a contact technique that is effective for tumor debulking by first coagulating the base with a probe followed by mechanical debulking with the bevel of the rigid bronchoscope.[34] Alternatively, the polypoid tumor can be removed by cutting through the stalk with a snare through the flexible bronchoscope (Figure 6).

EBES can be set to "cut," "coagulate," or "blend" by varying the amperage and voltage of electrical current. In a study that compared the degree of tissue injury caused by cut, coagulation, and blend modes, depth of tissue injury caused by coagulation current was significantly greater compared with blend and cut modes. Use of cutting current in the blend mode is recommended, because it is not only suitable for incision but also provides effective hemostasis with minimal tissue injury.[35]

Argon plasma coagulation (APC) is an electrosurgical modality in which equipment modifications allow electrical current to be applied in a noncontact mode through ionized argon gas, which acts as a conductor between electrode and tissue. It provides homogenous conduction of electrons, and also around corners making APC particularly useful for superficial hemorrhagic tumors, difficult to access upper lobe and superior basal lobar bronchial tumors[36,37] and granulation tissue around airway stents.[38]

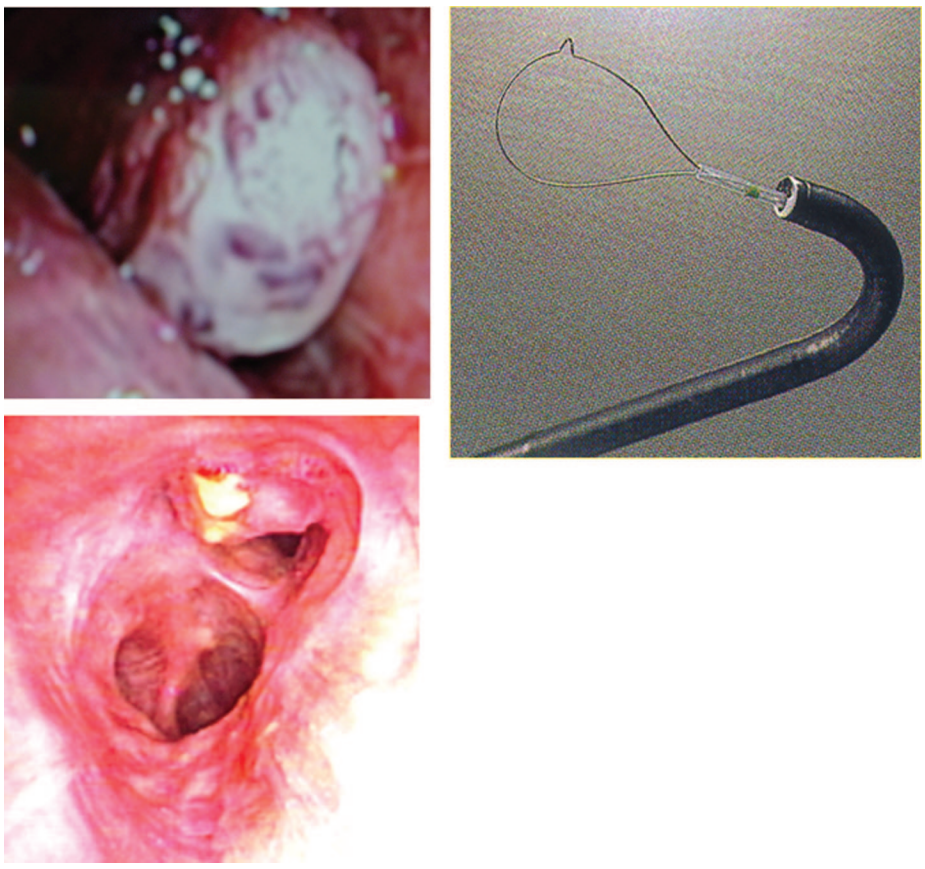


FIGURE 6. Polypoid endobronchial tumor in left main bronchus removed by electrosurgical snare.

Techniques for Delayed Airway Recannalization

Airway lesions that do not necessitate immediate restoration of airway patency can be treated with intraluminal brachytherapy, cryotherapy, or photodynamic therapy (PDT).

Brachytherapy

Brachytherapy refers to the temporary placement of encapsulated radioactive sources near or within an endobronchial or parabronchial malignancy to deliver local irradiation. The radioactive source can be implanted directly into the tumor, placed in the tumor bed after surgery, or through bronchoscopy. Improvements in the afterloading technique with iridium-192 enable bronchoscopic administration of high dose-rate brachytherapy on an outpatient basis with minimal hazard to healthcare personnel. The main advantage of this method is it allows high-dose irradiation of the tumor with rapid fall-off outside the treatment area. Brachytherapy is curative for early central airway cancers, small endobronchial and peripherally located tumors and can also be used for symptom palliation in patients who have received maximum dose of external beam irradiation.[39] However, it is contraindicated in tumors that invade major arteries or structures within the mediastinum, and complications include radiation bronchitis in 10% and hemoptysis in 7% of patients.[40,41]

Cryotherapy

Cryotherapy involves repetitive rapid cooling and slow thawing with a special probe that conducts liquid nitrogen or nitrous oxide. This results in intracellular ice-crystal formation that causes cell death and tissue destruction. Generally, three cycles of freezing and thawing are performed at each location and each freezing period lasts 20 seconds. Cryotherapy has been applied to treat malignant airway lesions,[42,43] and an ideal lesion for cryotherapy is a small, polypoidal tumor that is accessible to the probe with distal visibility of bronchial segments and functional lung. Cryotherapy is performed with the rigid or flexible cryoprobe and has been shown to potentiate the immunogenic effects of chemoradiation therapy.[42,44]

Although the action of cold on tissues causes delayed vascular thrombosis and necrosis, some investigators have used improved cryoprobes to remove large endobronchial tumors obstructing the central airways in which the cryoprobe tip is pushed into the protruding exophytic tumor, and freezing starts for about 5 seconds. The cryoprobe is abruptly removed together with tumor tissue frozen at the tip. The procedure is repeated until the tumor mass has been removed and the bronchus recannalized. Success in airway recanalization is more than 90% without complications, and clean up bronchoscopy is not required.[45] The same investigators have also reported that tissue specimens obtained with the cryoprobe are larger and of superior quality compared with those using the forceps.[46]

Photodynamic Therapy

PDT causes tissue necrosis through toxic oxygen radicals produced by the combined effect of a tumor-localizing photosensitizer dihematoporphyrin ether/ester (Photofrin, Axcan Pharma Inc., Birmingham, AL) and photons of appropriate wavelength (630 nm) delivered by an argon or diode laser. Photofrin is administered intravenously at 2 mg/kg and is retained preferentially by tumor, reticuloendothelial tissues, and skin. The tumor is then exposed to laser light 40 to 50 hours later, which initiates a chain reaction resulting in cell death by superoxide and hydroxyl radicals, and tissue necrosis by vascular thrombosis from thromboxane A2 release. Cleanup bronchoscopy is often necessary 2 to 4 days after the procedure. PDT is indicated for nonemergent palliation of obstructing tumors, treatment of synchronous and early lung cancers.[47–49]

Moghissi et al.[49] showed that when PDT was used to treat 100 patients with airway obstruction, airway patency improved by 68% with corresponding increases in forced vital capacity and forced expiratory volume in 1 second. Median survival after PDT was also better compared with other treatment modalities. Although complications of PDT are few such as dyspnea from airway obstruction because of tissue swelling, photosensitivity, and hemoptysis, its delayed effect precludes its use in acutely dyspneic patients. Need for regular cleanup bronchoscopy, avoidance of sunlight for 2 to 6 weeks depending on the photosensitizer and the relatively high cost make PDT less attractive.[47–49]

TABLE 2. Factors that Influence Outcome of Nd-YAG LPR

Factors	Favorable	Unfavorable
Location	Trachea, main bronchi	Lobar, segmental bronchi
Type of lesion	Endobronchial	Extrinsic
Appearance	Polypoid, exophytic, pedunculated	Submucosal
Extent of involvement	Localized (one wall)	Extensive (>1 wall)
Length of lesion	<4 cm	>4 cm
Distal lumen	Visible	Not visible
Duration of collapse	<4–6 wk	>4–6 wk
Clinical status		
Hemodynamics	Stable	Unsatble
Oxygen requirement	<40% FiO_2	>40% FiO_2
Coagulation profile	Normal	Abnormal
Pulmonary vascular supply	Intact	Compromised

Nd-YAG LPR, Neodymium-Yttrium-Aluminium-Garnet laser photoresection.

TABLE 3. Indications for Stent Placement

1 Airway obstruction from extrinsic bronchial compression or submucosal disease
2 Obstruction from endobronchial tumor when patency is <50% after bronchoscopic laser therapy
3 Aggressive endobronchial tumor growth and recurrence despite repetitive laser treatments
4 Loss of cartilaginous support from tumor destruction
5 Sequential insertion of airway and esophageal stents for tracheoesophageal fistulas

EXTRINSIC AIRWAY COMPRESSION

Stents

Airway stent insertion is effective in maintaining airway patency from extrinsic airway compression due to tumor. Available types include silicone tube, covered and uncovered metallic, and hybrid stents. Table 2 describes the indications for stent placement and Table 3 illustrates the differences between silicone tube and metallic stents.

Silicone Tube Stents

These stents are advantageous because they can be customized to conform to the airways (Figure 7). The silicone Y stent can be used if the distal trachea, bifurcation, and proximal bronchi are compressed or infiltrated by tumor. Silicone stents can be easily repositioned and removed, and is less expensive. However, they are associated with a higher migration rate and require the rigid bronchoscope for insertion.[50,51]

Metallic Stents

These stents can be placed with the flexible bronchoscope under local anesthesia in an outpatient setting (Figure 8). They have greater airway cross-sectional diameters, conform better to tortuous airways, and allow for mucociliary clearance and ventilation across a lobar bronchial orifice (Table 4).[52] Major disadvantages include obstructing granuloma, cracks from metal fatigue, and difficulty in removal or repositioning after epithelialization has occurred.[53] Because tumors can grow through the gaps of uncovered metallic

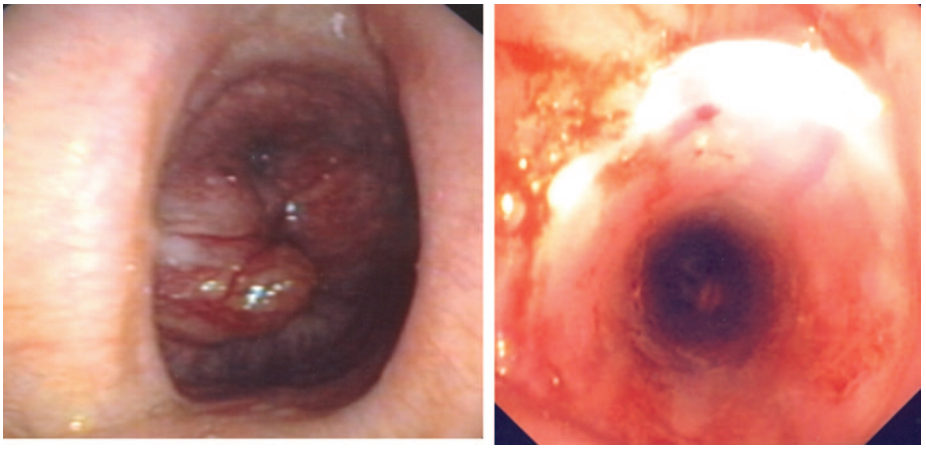


FIGURE 7. Adenoidcystic carcinoma of trachea with near total obstruction. Laser photoresection of obstructing tumor via rigid bronchoscopy and silicone stent insertion.

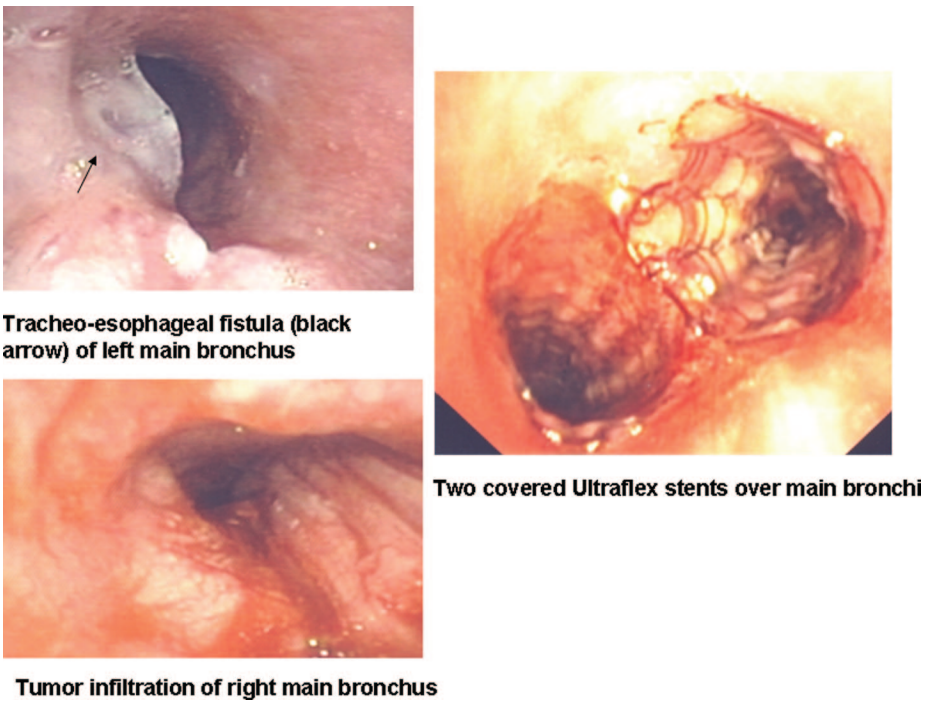


FIGURE 8. Tracheoesophageal fistula with covered Ultraflex stent performed using flexible bronchoscopy at outpatient setting.

stents, covered ones with silicone membrane of appropriate size and length should be used. If the airway becomes occluded by tumor ingrowth or granulation tissue, laser should be avoided, because covered metallic stents are flammable, cryotherapy or APC used in conjunction with brachytherapy are safe and effective alternatives.[38,41,42] A new self-expanding nitinol Y stent has been described for treatment of central tumors affecting the distal trachea, bifurcation, and proximal main bronchi.

TABLE 4. Comparison of the Dumon Stent and the Covered Ultraflex Stent

Characteristics	Dumon Stent	Covered Utraflex Stent
Mechanical considerations		
High internal to external diameter ratio	−	+++
Resistant to recompression when deployed	+	++
Radial force exerted uniformly across stent	+	++
Absence of migration	−	++
Flexible for use in tortuous airways	−	+++
Removable	+++	−
Dynamic expansion	−	++
Can be customized	+++	−
Tissue-stent interaction		
Biologically inert	++	++
Devoid of granulation tissue	+	−
Tumor ingrowth	++	+
Ease of use		
Can be deployed with FB	−	+++
Deployed under local anesthesia with conscious sedation	−	++
Radiopaque for position evaluation	−	+++
Can be easily repositioned	++	−
Cost		
Inexpensive	+	−

−, poor; +, fair; ++, good; +++, best.

EARLY LUNG CANCER DETECTION AND INTERVENTION

Five-year survival of lung cancer remains dismal at 16%[54] and is conceivable that better outcome can be achieved if lung cancer is diagnosed and treated early. Improved CT imaging can detect peripheral tumors, those occurring in the central airways that are radiographically invisible, they can be diagnosed by sputum cytology and bronchoscopy.[55] As these preinvasive lesions show subtle changes such as redness, thickening, and granular appearance, it is not surprising that only 30% are detected by white light bronchoscopy.[56] Moderate dysplasia has 11% risk, whereas severe dysplasia and carcinoma in situ have 40 to 83% risk of progression to invasive lung cancer.[57] Localizing these preinvasive lesions would allow local treatment or lung conservation strategy.

Autofluorescence Bronchoscopy

When bronchial surface is illuminated by light, light can be absorbed, reflected, back scattered, or induce fluorescence. Reflectance imaging (e.g., white light bronchoscopy) defines structural features of bronchial epithelium to discriminate normal from abnormal, whereas autofluorescence (AF) bronchoscopy depends on the concentration of fluorophores in the bronchial tissue. Normal bronchial epithelium fluoresces in green when illuminated by blue light, because it transforms through different grades of dysplasia, carcinoma in situ to invasive cancer a progressive decline in green fluorescence due to increased epithelial thickness and tumor neovascularization occurs, making these abnormal areas appear red. The spectral differences between 500 and 700 nm for normal, preneoplastic, and neoplastic tissues serve as basis for the development of AF-reflectance imaging devices such as OncoLIFE, D-light, SAFE 3000, and AFI. Numerous studies have consistently demonstrated superiority of AF during white-light bronchoscopy for the detection of preinvasive lesions and early lung cancer. However, AF has a high false-positive rate when bronchitis or airway inflammation is encountered.[58–61]

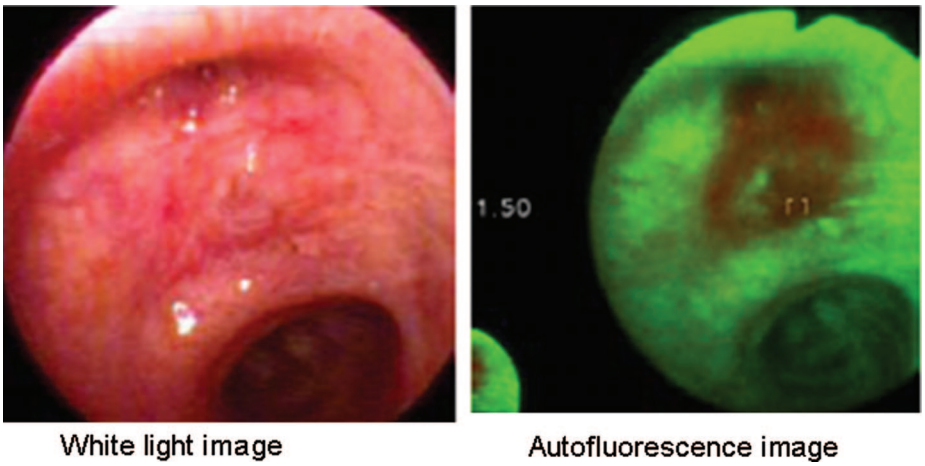


FIGURE 9. Color fluorescence (red/green) ratio of carcinoma in situ.

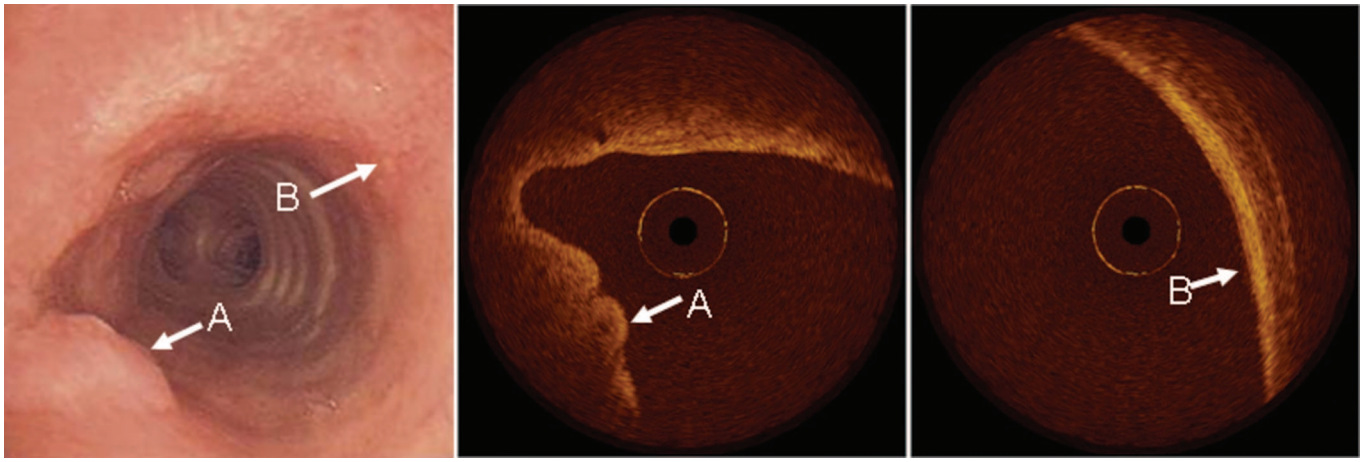


FIGURE 10. Squamous cell carcinoma of trachea. Bronchoscopic images: (*A*) nodular tumor and (*B*) normal tracheal wall optical coherence tomography (OCT) images: Tumor (*A*) infiltrating beyond the cartilage and (*B*) normal OCT.

Our recent evaluation of real-time simultaneous video- and AF-imaging using SAFE 3000 demonstrated good sensitivity (0.85) for the detection of preinvasive lesions with improved specificity (0.94) for targeted biopsy, which led to a marked decrease in procedural time.[62] By calculating the red to green ratio of the abnormal airway site, we have also shown that a derived color fluorescence ratio of 0.54 or more correlated with the histologic finding of moderate to high-grade dysplasia and could serve as an objective guide to biopsy (Figure 9).[63]

Narrow band imaging (NBI) technology that uses two wavelengths of light namely blue light (390–440 nm) that is absorbed by superficial capillaries and green light (530–550 nm) by blood vessels beneath the mucosa enhances visualization of vascular patterns of the tracheobronchial tree. Previous studies have demonstrated correlation between bronchial vascular pattern and angiogenic squamous dysplasia recognized as precursor of early cancer and a more sensitive bronchoscopic imaging tool for the detection of preneoplasia.[64,65] In a recent report by Herth et al.,[66] NBI was found to be more specific than AF without compromising sensitivity in the detection of airway preneoplastic lesions.

Bronchoscopic Treatment of Early Lung Cancer

Precise staging of early central airway cancer is extremely important for the selection of appropriate treatment. Although surgery is still the preferred option, many patients harboring these cancers have smoking-related comorbidities that place them at high surgical risk. Moreover, 20 to 30% of these early cancers are multifocal,[67] highlighting the need for lung preservation strategies, which propel bronchoscopic techniques forward as attractive alternatives.

The criteria of early central airway cancers suitable for bronchoscopic treatment must first be radiographically occult, without lymph node and distant metastasis. The squamous cell cancer should measure less than 2 cm in greatest dimension with visible distal margin and confined within the cartilaginous layer of the tracheobronchial tree.[55,68] Investigators are suggesting multimodality approach that includes the combined use of high resolution CT, positron emission tomography, AF, and EBUS to accurately stage these early cancers to aid selection of appropriate therapy.[69–71]

To date, PDT is the most established treatment for early central airway cancers with 60% 5-year survival and more than 90% cancer-specific survival.[72] Complete response was also achieved in 97% of patients with early cancers ≤ 1 cm^2 treated with EBES.[70] Other bronchoscopic techniques demonstrating good tumor response include high dose rate-brachytherapy (85%) and cryotherapy (97%).[73,74]

RESEARCH IN TUMOR MARKERS AND NEW DIAGNOSTIC OPTICAL TECHNOLOGIES

Bronchoscopy offers researchers access into the lung and biomarkers have been developed to prognosticate and identify individuals at risk for lung cancer.[75] Sensitive bronchoscopic techniques such as AF and NBI allow early detection and detailed characterization of microvascular patterns to advance the understanding of angiogenesis and its role in early carcinogenesis; Raman spectroscopy that measures biochemical composition and metabolic state of bronchial tissues facilitates differentiation of preinvasive from benign lesions[76]; and confocal microendoscopy that provides cellular images are novel imaging methods to study lung carcinogenesis.[77]

Optical coherence tomography (OCT) detects backscattered light instead of sound waves, and because light is 200,000 times faster than sound, low coherence interferometry is required to integrate reflectance properties of tissue scanned to produce high-resolution cross-sectional microimages. For the airway, OCT can display structures of the bronchial wall in great detail and potentially allows real-time noninvasive histologic imaging without the actual performance of biopsy (Figure 10). OCT and confocal microendoscopy may be nonbiopsy tools to facilitate our understanding of the evolution of preinvasive lesions and the effect of chemopreventive intervention.[78,79] Whether OCT and confocal microendoscopy will be more precise for tumor assessment require investigation.

CONCLUSION

These are indeed exciting times for clinicians and scientists interested in lung cancer detection and therapy. Biomarkers, novel imaging tools, and techniques improve cancer detection at the early stages and when combined with precise staging allow institution of lung preservation strategies. Research into tumor markers and receptors pursue an era for targeted and cancer-specific therapies, which demonstrate greater efficacy and with fewer adverse effects.[80] Although randomized clinical trials in diagnostic and therapeutic bronchoscopy are few, use of appropriate technologies depends on the skill of the bronchoscopists and availability of equipment. In patients with advanced lung cancer for whom palliation is required, opportune use of interventional bronchoscopic techniques provide symptom relief, longer survival, and improved quality of life.

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